

WE CLAIM:

1 1. A copper electroplating bath, comprising:
 2 water as a solvent;
 3 copper ions;
 4 anions that strongly complex said copper ions so as to substantially increase
 5 the overpotential for copper electrodeposition such that the copper deposition rate at a
 6 given cathode potential is substantially suppressed; and
 7 an organic additive compound that tends to accelerate the copper
 8 electrodeposition rate.

1 2. The copper electroplating bath of Claim 1, wherein said anions are of a type
 2 selected from the group consisting of pyrophosphate, cyanide, citrate, tartrate, phosphate,
 3 glycerolate, ethylenediaminetetraacetic acid, carboxylic acids, triethanolamine, amines,
 4 phosphonates, and mixtures thereof.

1 3. The copper electroplating bath of Claim 1, further comprising:
 2 cations other than copper ions added to the electroplating bath as a salt of said
 3 anions, such that said anions are present in the electroplating bath in stoichiometric
 4 excess relative to said copper ions.

1 4. The copper electroplating bath of Claim 3, wherein said cations other than
 2 copper ions are not electroactive at the potential used for copper electrodeposition, such that
 3 relatively pure copper metal is deposited.

1 5. The copper electroplating bath of Claim 4, wherein said cations other than
 2 copper ions are selected from the group consisting of K^+ , Na^+ , and NH_4^+ ions.

1 6. The copper electroplating bath of Claim 1, further comprising:
 2 a surfactant.

1 7. The copper electroplating bath of Claim 1, further comprising:

ions of at least one electroactive metal selected from the group consisting of silver, zinc, cadmium, iron, cobalt, nickel, tin, lead, bismuth, antimony, gallium and indium, such that a copper alloy deposit is obtained.

8. The copper electroplating bath of Claim 1, wherein said organic additive compound contains at least one chemical element selected from the group consisting of sulfur, nitrogen and phosphorous.

9. The copper electroplating bath of Claim 1, whereby copper metal is electrodeposited in Damascene trenches and vias to form circuitry on semiconductor chips.

10. A copper electroplating bath, comprising:
water as a solvent;
copper ions;
pyrophosphate anions;
cations other than copper ions added to the electroplating bath as a salt of said anions, such that said anions are present in the electroplating bath in stoichiometric excess relative to said copper ions; and
an organic additive compound that tends to accelerate the copper electrodeposition rate.

11. The copper electroplating bath of Claim 10, wherein said cations other than copper ions are not electroactive at the potential used for copper electrodeposition, such that relatively pure copper metal is deposited.

12. The copper electroplating bath of Claim 11, wherein said cations other than copper ions are selected from the group consisting of K^+ , Na^+ , and NH_4^+ ions.

13. The copper electroplating bath of Claim 10, further comprising:
a surfactant.

1 14. The copper electroplating bath of Claim 13, wherein said surfactant is
2 polyoxyethylene(10)isooctylphenylether.

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1 15. The copper electroplating bath of Claim 10, further comprising:
2 ions of at least one electroactive metal selected from the group consisting of
3 silver, zinc, cadmium, iron, cobalt, nickel, tin, lead, bismuth, antimony, gallium and
4 indium, such that a copper alloy deposit is obtained.

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1 16. The copper electroplating bath of Claim 10, wherein said organic additive
2 compound is 2,5-dimercapto-1,3,4-thiadiazole at a concentration in the range from 1 to 5
3 μM .

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1 17. The copper electroplating bath of claim 10, wherein the temperature is
2 maintained between 50°C and 60°C.

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1 18. The copper electroplating bath of Claim 10, wherein the pH is maintained in
2 the 8.0 to 8.8 range.

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1 19. The copper electroplating bath of Claim 10, further comprising;
2 ammonia or ammonium ion.

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1 20. The copper electroplating bath of Claim 10, further comprising:
2 nitrate ion.

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1 21. The copper electroplating bath of Claim 10, whereby copper metal is
2 electrodeposited in Damascene trenches and vias to form circuitry on semiconductor chips.

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1 22. A copper electroplating bath, comprising:
2 water as a solvent;
3 copper ions;
4 pyrophosphate anions;

5 cations other than copper ions added to the electroplating bath as a salt of said
 6 anions, such that said anions are present in the electroplating bath in stoichiometric
 7 excess relative to said copper ions; and
 8 2,5-dimercapto-1,3,4-thiadiazole at a concentration in the range from 1 to 5
 9 μM ,
 10 whereby copper metal is electrodeposited in Damascene trenches and vias to form
 11 circuitry on semiconductor chips.

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 1 23. A copper electroplating bath, comprising:
 2 water as a solvent;
 3 copper ions;
 4 pyrophosphate anions;
 5 cations other than copper ions added to the electroplating bath as a salt of said
 6 anions, such that said anions are present in the electroplating bath in stoichiometric
 7 excess relative to said copper ions;
 8 an organic additive compound that tends to accelerate the copper
 9 electrodeposition rate; and
 10 a surfactant.

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 1 24. A copper electroplating bath, comprising:
 2 water as a solvent;
 3 copper ions;
 4 pyrophosphate anions;
 5 cations other than copper ions added to the electroplating bath as a salt of said
 6 anions, such that said anions are present in the electroplating bath in stoichiometric
 7 excess relative to said copper ions;
 8 2,5-dimercapto-1,3,4-thiadiazole at a concentration in the range from 1 to 5
 9 μM ; and
 10 a surfactant,
 11 whereby copper metal is electrodeposited in Damascene trenches and vias to form
 12 circuitry on semiconductor chips.

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1 25. A copper electroplating bath, comprising:
2 water as a solvent;
3 copper ions;
4 pyrophosphate anions;
5 cations other than copper ions added to the electroplating bath as a salt of said
6 anions, such that said anions are present in the electroplating bath in stoichiometric
7 excess relative to said copper ions;
8 2,5-dimercapto-1,3,4-thiadiazole at a concentration in the range from 1 to 5
9 μM ,
10 polyoxyethylene(10)isooctylphenylether as a surfactant;
11 ammonia or ammonium ion; and
12 nitrate ion,
13 whereby copper metal is electrodeposited in Damascene trenches and vias to form
14 circuitry on semiconductor chips.

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1 26. A process for electrodepositing copper circuitry in trenches and vias on
2 semiconductor chips, comprising the steps of:
3 providing a semiconductor chip with trenches and vias to be filled with
4 copper;
5 placing said chip in contact with an electroplating bath, said bath comprising:
6 water as a solvent,
7 copper ions,
8 pyrophosphate anions,
9 cations other than copper ions added to the electroplating bath as a salt
10 of said anions, such that said anions are present in the electroplating bath in
11 stoichiometric excess relative to said copper ions, and
12 2,5-dimercapto-1,3,4-thiadiazole at a concentration in the range from 1
13 to 5 μM , and
14 electrodepositing copper in said trenches and vias.

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1 27. The process of Claim 26, wherein said cations other than copper ions are
2 selected from the group consisting of K^+ , Na^+ , and NH_4^+ ions.

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1 28. The process of Claim 26, wherein the electroplating bath further comprises a
2 surfactant.

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1 29. The process of Claim 28, wherein said surfactant is
2 polyoxyethylene(10)isooctylphenylether.

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1 30. The process of Claim 26, wherein the temperature of the plating bath is
2 maintained at a temperature between 50°C and 60°C.

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1 31. The process of Claim 26, wherein the pH of the electroplating bath is
2 maintained in the 8.0 to 8.8 range.

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1 32. The process of Claim 26, wherein the electroplating bath further comprises
2 ammonia or ammonium ion.

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1 33. The process of Claim 26, wherein the electroplating bath further comprises
2 nitrate ion.